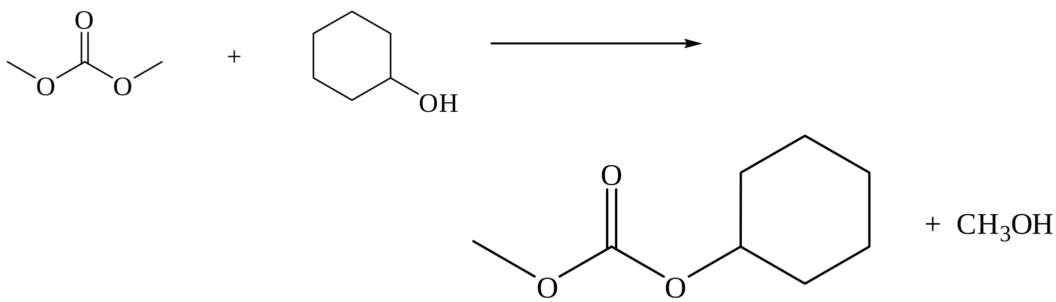
CHEM1102 Answers to Problem Sheet 7

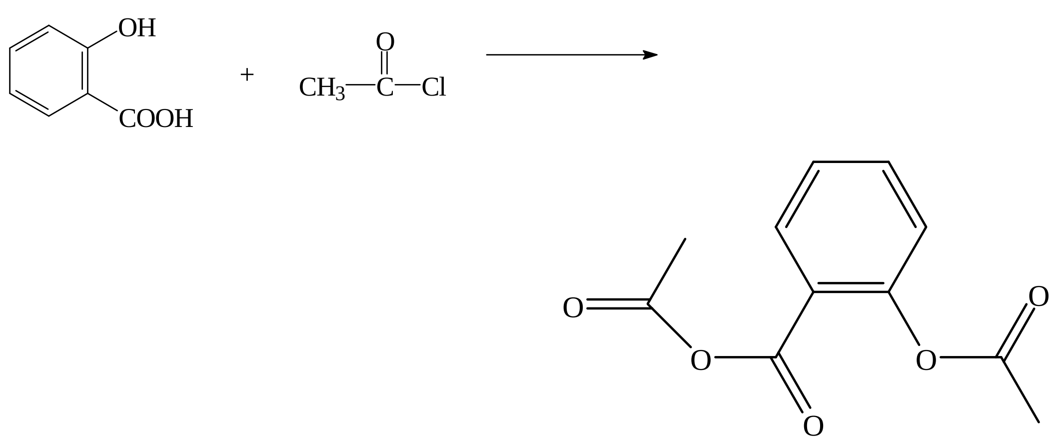
1. (a)

N,3-dimethylbutanamide

(b)

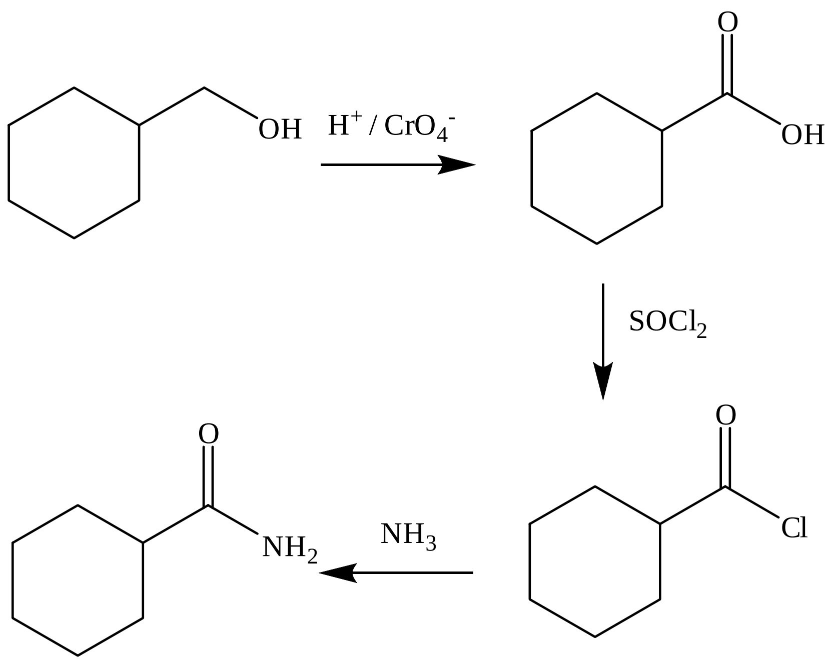


(c)

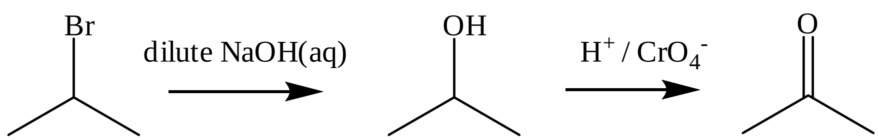


acetic 2-acetoxybenzoic anhydride

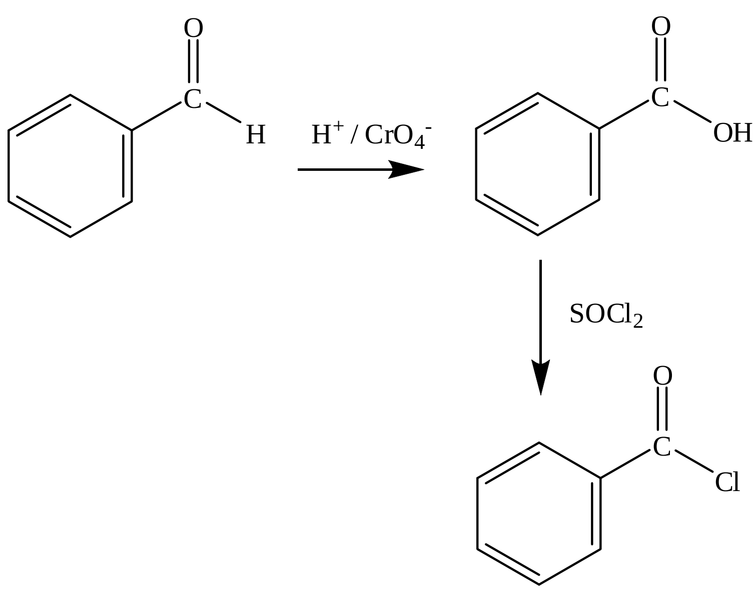
2. (a)


OH
H+ / CrO4-
O
OH
SOCl2
O
Cl
NH3
O
NH2

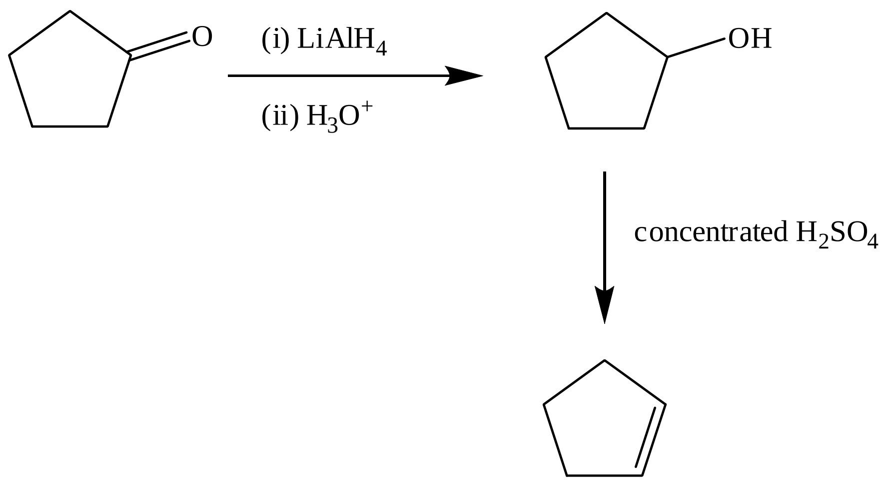
(b)


Br
dilute NaOH(aq)
OH
H+ / CrO4-
O

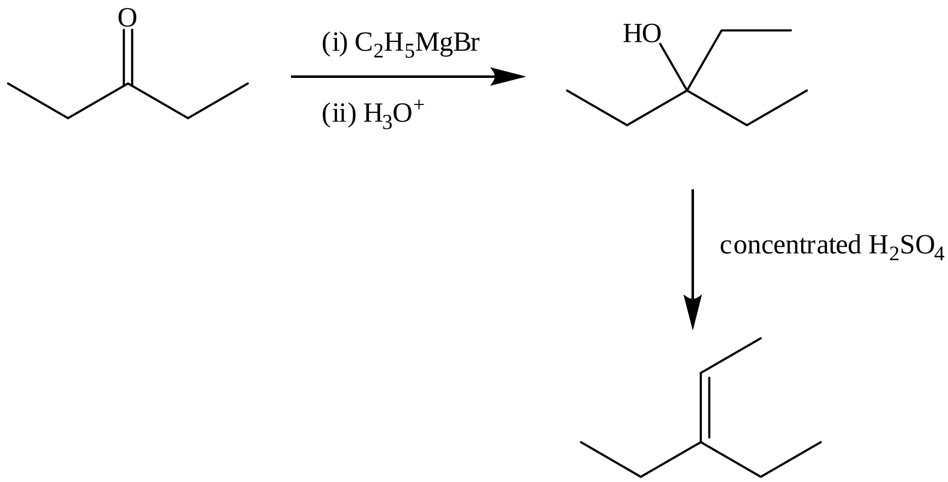
(c)


O
C
H
H+ / CrO4-
O
C
OH
SOCl2
O
C
Cl

(d)



(e)



3. (a)

(i) **The titration is a 1:1 reaction between a strong acid and a strong base. Before any base is added, $[H^+(aq)] = 0.100$ M and so pH = $-\log_{10}(0.100) = 1.00$.**

(ii) **As $OH^-(aq)$ is added, the $[H^+(aq)]$ decreases.**

This is due to the acid-base reaction and due to the increase in volume.

Up until the equivalence point:

$$[H^+(aq)] = \frac{n_{H^+}}{V} = \frac{n_{H^+}(\text{initial}) - n_{OH^-}(\text{added})}{V_{total}}$$

or

$$[H^+(aq)] = \frac{(c_{H^+}(\text{initial}) \times V(\text{initial})) - (c_{OH^-}(\text{added}) \times V(\text{added})}{(V(\text{initial}) + V(\text{added}))}$$

Thus, when 25.0 mL of 0.100 M NaOH has been added:

$$[H^+(aq)] = \frac{(0.100\,\text{M} \times 0..050\,\text{L}) - (0.100\,\text{M} \times 0.025\,\text{L})}{((0.050 + 0.0250)\,\text{L})} = 0.033\text{ M}$$

Hence, pH = -log$_{10}$(0.033) = 1.48

(iii) **When 45.0 mL of 0.100 M NaOH has been added:**

$$[\mathbf{H^+(aq)}] = \frac{\mathbf{(0.100\,M \times 0..050\,L) - (0.100\,M \times 0.045\,L)}}{\mathbf{((0.050 + 0.0450)\,L)}} = \mathbf{0.0053\ M}$$

Hence, pH = -log$_{10}$(0.0053) = 2,28

(iv) **Addition of 50.0 mL of 0.100 NaOH will exactly neutralize the acid.**

Hence, pH = 7.00

(v) **Beyond the equivalence point, the added base is simply being diluted as there is no acid left to react with:**

$$[\mathbf{OH^-(aq)}] = \frac{n_{\mathrm{OH^-}}}{V} = \frac{n_{\mathrm{OH^-}}\mathbf{(total)} - n_{\mathrm{H^+}}\mathbf{(initial)}}{V_{total}}$$

As 50.0 mL of 0.100 M HCl was present initially, $n_{\mathrm{H^+}}$(initial) = 5.00 × 10^{-3} mol.

55.0 mL of 0.100 M NaOH corresponds to 5.50 × 10^{-3} mol and when this has been added, the total volume is (0.050 + 0.055) L = 0.105 L. Hence

$$[\mathbf{OH^-(aq)}] = \frac{\mathbf{(0.00550\,mol) - (0.00500\,mol)}}{\mathbf{(0.105\,L)}} = \mathbf{0.00476\ M}$$

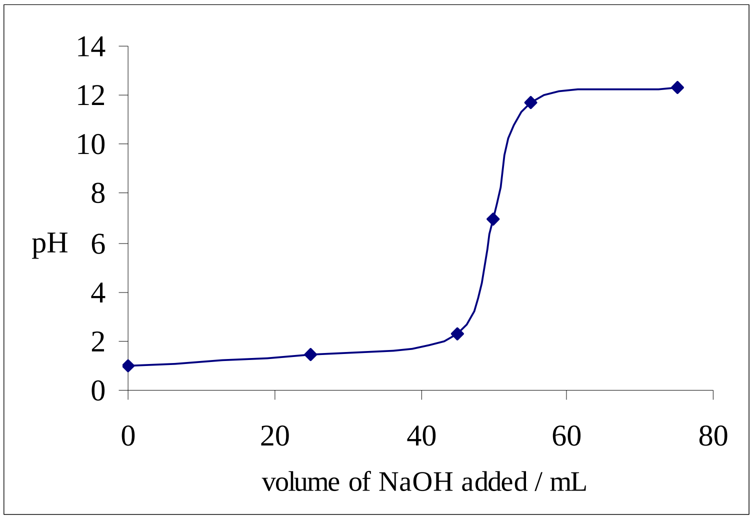
Hence, pOH = -log$_{10}$(0.00476) = 2,32 and pH = 14.00 – 2.32 = 11.7

(vi) **When 75.0 mL of 0.100 M NaOH has been added, $n_{\mathrm{OH^-}}$(total) = 7.50 × 10^{-3} mol and the total volume is (0.050 + 0.075) L = 0.125 L. Hence**

$$[\mathbf{OH^-(aq)}] = \frac{\mathbf{(0.00750\,mol) - (0.00500\,mol)}}{\mathbf{(0.125\,L)}} = \mathbf{0.0200\ M}$$

Hence, pOH = -log$_{10}$(0.0200) = 1.70 and pH = 14.00 – 1.70 = 12.3

(b) **Using these values, the pH curve for the titration can be constructed and is shown below.**



4.

Acid	Base	Acid	Base
HCl	**Cl^-**	HCO_3^-	**CO_3^{2-}**
CH_3CH_2COOH	**$CH_3CH_2COO^-$**	**H_2CO_3 (or $H_2O + CO_2$)**	HCO_3^-
HPO_4^{2-}	PO_4^{3-}	**NH_4^+**	NH_3
HCN	CN^-	$CH_3CH_2NH_3^+$	**$CH_3CH_2NH_2$**